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ESTABLISHMENT OF HYDROLOGICAL NETWORK FOR RIVER BASIN DEVELOPMENT

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ESTABLISHMENT OF HYDROLOGICAL NETWORK FOR RIVER BASIN DEVELOPMENT

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I. ADMINISTRATIVE PROBLEMS RELATING TO DEVELOPMENT OF WATER RESOURCES

1. It is a very obvious fact that water is indispensable to human life, but people living in civilized society now do not appreciate it so much. On the other hand, to people living on deserts and solitary islands in the ocean, and in areas of small precipitation, water is more precious than money. In other words, it may be said that the relation between water and man is subject to the difference in the natural conditions. Furthermore, this relation differs according to the age; it cannot but change greatly as a result of a change in the industrial structure and advancement in the mode of living.

2. From the standpoint of water utilization, the rate of utilization is low in spite of the fact that water is indispensable to man. For a long time it was merely used for irrigation and municipal water services. It was only very recently that water was taken up as one of the important resources of the secondary industry and its importance was first recognized. In areas where the relative importance of the primary industry is very great, the utilization of water is primarily for agriculture, and particularly when the type of agriculture is one which consists principally of rice crop production as in Southeast Asia, there can be no agriculture unless utilization of water is taken into consideration. Conversely speaking, it may be said that it is agriculture itself which is the most affected by floods. It is natural that the characteristics of floods should differ very much according to the meteorological and geographical conditions and also that transitions in the economic and social backgrounds of a country should bring about changes in her people's way of thinking concerning floods. At the same time, political and administrative measures cannot but alter in accordance with such changes.

3. If we look back on the history of the system for controlling and utilizing water and that of water administration in Japan as an example, we can well understand the above statements. First, flood control projects have been a matter of concern of the successive governments. In fact, such projects in Japan may be traced back to A.D. 300 or so. In modern times, the River Law was enacted in the Meiji era, and the administration of water has been performed mainly from the standpoint of flood prevention. That is to say, politically the primary concern has been flood prevention. As regards the water utilization aspect, in formulating an administrative plan of agricultural water utilization, the practice has been to take it up chiefly from the standpoint of land improvement, the stand of the farmers themselves not always being positively considered. The tendency has been to look upon water as something existing naturally. Secondly, the remarkable growth of demand for water in recent years, that is, the increase in demand for municipal service water due to the change in the mode of living and for industrial water due to the expansion of the production scale is making it necessary to drastically reform the legislation relative to water. In other words, there is an increasing recognition of the fact that water is something produced by science and technics and, moreover, that it is not meant for any specified people or social circles but should be utilized for the public benefit. In the field of administrative system too, the time has come to work for its integration and adjustment to

meet the situation.

4. In Japan, the administration of water is now divided among several Ministries according to the purpose ——— Ministry of Construction (flood control), Ministry of Agriculture and Forestry (irrigation), etc., and legal rights and interests are asserted by the respective interested groups. Under these circumstances, it is extremely difficult to attain integrated utilization of water resources based on a national viewpoint. However, when we consider the essential nature of administration, the most important thing is to protect the national and public interests. The recent trend in the administration for development and utilization of water resources is that it must be done based on modern scientific techniques. This is seen in the unified development projects to be carried out by the Water Resources Development Corporation with the aim of promoting coordinated development and utilization for each of the river systems in areas where the demand for water is conspicuously high, as provided for in the recently enacted Law for Promoting Development of Water Resources.

5. Administrative problems relating to development of water resources vary with the country according to her historical background. We must know that there are involved many factors which cannot be solved merely by technical measures for water utilization.

II. HYDROLOGICAL OBSERVATION IN JAPAN

6. Hydrological observation generally means the measurement of precipitation and the observation of water-stage and discharge of the river. Seen from the standpoint of purpose, observation stations may also be divided in another way into two types: those established for the purpose of flood control and those for water utilization. Of course, some are established for the double purpose and some others for water utilization are intended not for the general water utilization but for a special purpose of water utilization. With regard to the business of such observation in Japan, the general observation of precipitation is conducted by the Meteorological Agency in accordance with the Meteorological Business Law and the outflow of the main rivers by the Ministry of Construction. The observation of the outflow of smaller rivers is conducted by the respective local public bodies (i.e. prefectures) which are responsible for their administration. Needless to say, observation for other purposes, for instance precipitation measurement intended for irrigation and water stage observation for power generation, is also conducted by the Ministry of Agriculture and Forestry and power companies respectively.

7. An outline of these observation networks in Japan is given in Table 1 so

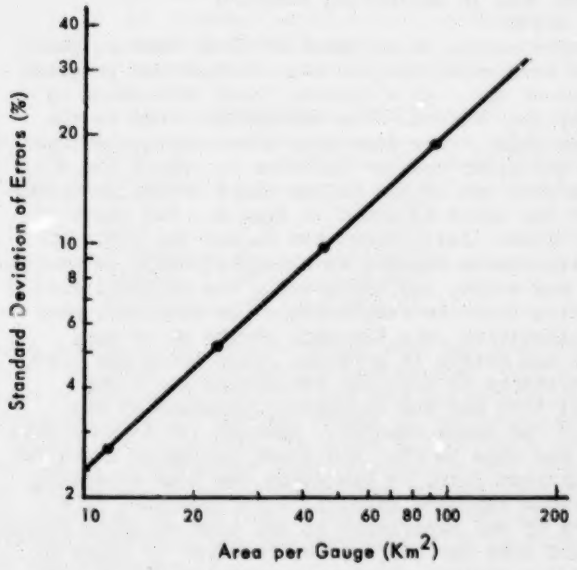
Table 1. Numbers of Hydrological Observation Stations throughout Japan

	Meteorological Agency	Ministry of Construction	Ministry of Agriculture and Forestry	Ministry of International Trade and Industry
Precipitation measurement stations	2,022	1,300	679	3
Discharge observation stations	0	515	0	24

	Maritime Safety Agency or Defence Agency	National railways	Prefectures, cities, towns and villages	Power companies	Others	Total
Precipitation measurement stations	35	313	2,066	717	415	7,550
Discharge observation stations	0	0	273	435	20	1,267

as to show their scales. According to the Table, the average density of the precipitation measurement stations is 49 km^2 per station and that of the discharge observation facilities is 1 station for every 70 km of river length. As there are different organs in charge of the precipitation measurement facilities, it sometimes happens that few observation stations are placed at the same point, and so it is necessary to reduce the figures in their analysis or evaluation. It is a very difficult question on what basis the density of these observation networks should be decided. In deciding the most economical network which attains the accuracy necessary for the specified purpose, the geographical and meteorological conditions should be taken into consideration.

8. Let us consider establishing a precipitation measurement network for the purpose of developing water resources. In this case the aim of the precipitation measurement network is to obtain a long-range and macroscopic grasp of the quantity of water available from the river system. Recently, the Public Works Research Institute of the Ministry of Construction conducted a study of the relation between the average rainfall in the mountain district of the basin and the density of the precipitation measurement station network. The study, by utilization of the 31 precipitation measurement stations established in the area of 373.6 km^2, analyzed the relation between the area governed by one observation station and the standard deviation of the relative error from the correct value by observing many a continuous rainfall, the results being given in Fig. 1. It is considered that this relation changes with the total area of the basin and that the accuracy is improved with the increase of the area of the basin. Mr. Ray K. Linsley refers in his book to the results of the similar analysis made by the U.S. Weather Bureau. Considering the largeness of the basin area, a similar tendency is observed there. In Fig. 1, 10% in the standard deviation corresponds to 50 km^2 of area governed by one station, which density will be generally sufficient for calculation of the average precipitation in the basin. These values represent records in the mountain districts of Japan which, under the influence of typhoons and 'Baiu' fronts, are subject to local changes and where the conditions are different according to the locality. For other regions, it will usually be possible to enlarge the governing area per station.



9. Water-stage observation stations and discharge observation stations are usually operated by the Ministry of Construction or local public bodies. The primary object of the observation is to utilize the results for flood control, or, more concretely, flood alarm, river improvement, etc. In recent years, however, it has become necessary to give full consideration to rational allocation of water resources in order to meet the increasing demand for water, and so it is natural that the arrangement or placing of the stations should now be different from that in the days when flood control was the only consideration. With regard to the method of working

out a coordinated plan of the demand and supply of water, we may follow this method: ——— for a river system, to select 1 or 2 discharge observation stations as basic stations, to select 2 or 3 years when water dearth was severe out of the past ten years on the basis of the obtained data of discharge, and to examine the relation between supply and demand on the basis of the flow at the water dearth. In selecting the said basic stations, the two following conditions should be considered: (a) spot where the river has just entered the plain coming down from the mountain district and where the effect of the water supply and drainage in the upper stream can be neglected in planning the demand and supply of water, and (b) that the hydrometry data cover a long period. This method has been adopted in Japan taking into consideration the geographical conditions and the situation of water utilization of the country. In analyzing water resources for the use in the lower reaches, the water use for irrigation in the upper reaches may be neglected, because most part of the water used for irrigation flows underground and rejoins the main stream. Except in special cases like diversion in the upstream, industrial water and domestic water are usually taken in the alluvial plains after the river has passed through the mountain district in this country. Therefore, the said basic stations are very effective for analysis of the supply-demand relation.

10. In paragraphs 8 and 9 were explained the rules or standards for locating observation stations. Such standards should vary according to the geographical and climatic conditions, to the actual situation of supply and demand of water and to the plan. They must be selected so as to be arranged rationally to meet the respective purposes.

III. ANALOGUE COMPUTER USED IN ESTIMATING FLOODING OF THE KITAKAMI RIVER

11. As a link in the chain of comprehensive development of river basins, there have been worked out and carried out many multi-purpose dam construction programs in this country since the termination of war. As a result, flood prevention by means of dams has become more popular than before. One example is found in the case of the Kitakami river basin, for which three dams have been constructed and two others are to be constructed in the upper reaches in order to reduce the discharge of the main stream by 2,000 m^3/sec out of the design flood discharge 9,000 m^3/sec at Ichinoseki. An outline of the basin is shown in Fig. 2. The basin of the Kitakami lies between the Ou and the Kitakami mountain chains forming an elongated shape extending north and south, and accordingly the rainfall distribution there is complicated. In addition, many big tributaries join the main stream at so many points and affect it greatly. Such being the case, much prudence is required concerning the flood control plan and the discharge operation of the dams in the upper reaches. However, it demands much labor and time to find the flood discharge curve for a downstream point by operating the dams according to various supposed rainfall distributions. The results of our experience at the time of three floods revealed that the computation requires 50 hours by use of the digital electronic computer (FACOM 128B Relay Type). Accordingly, a new analogue flood computer is being manufactured aiming at (a) establishing a rational plan for improving the rivers of the Kitakami System, (b) reducing the time needed for flood forecast and improving the accuracy of forecast, (c) attaining rational and unified operation of the five dams, etc.

Fig. 2

(see page 6)

12. Details of the computer are omitted on account of space consideration, but in the following will be given an explanation of the pluviometry network which serves as the basis of calculation: ——— With respect to the river channel, the area is divided into 7 blocks along

the main stream as shown in Fig. 3. In computing the precipitation, the retarding effect of the transversal inflow that contributes to the mainstream in each block was considered. In Fig. 3, the precipitation measurement stations are also given. From the records of the stations, the average rainfall in the basin was obtained by Thiessen's method. Then 2-4 other stations closely related to them were selected and the formula expressing the daily average rainfall in the basin was estimated on the basis of the records of these stations. For instance, the relation between the records of the station in Block III and the average daily rainfall of the basin was as shown in Table 2. Based upon this, two representative stations were considered as shown in Table 3. The precipitation measurement stations in all the

Table 2. Relation between Representative Precipitation Measurement Stations and Average Daily Rainfall

No. of block	Name of precipitation measurement station	Correlation coefficient	
		Baiu type	Typhoon type
III	Dake	0.959	0.849
	Toyozawa	0.890	0.865
	Ōhazama	0.930	0.950
	Namari	0.887	0.941
	Ontoku	0.929	0.938
	Shimetsukeumaushi	0.955	0.955
	Hanamaki	0.916	0.956
	Tase	0.901	0.949
	Tōno	0.957	0.864
	Ashigashe	0.872	0.769

Coefficient for representative precipitation measurement station:

$I = \alpha a_i + \beta b_i + \gamma c_i$

I: Average areal daily rainfall

α, β, γ : Coefficient

a_i, b_i, c_i : Daily rainfall in a, b, c

Table 3. Correlation Coefficient

No. of block	Name of station		Coefficient in formula to calculate average daily rainfall	
			'Baiu' type	Typhoon type
III	Dake	α	4.5963368	2,2244161
	Tase	β	2.2095607	3.9603779
	Hanamaki	γ	3.2642935	3.8070117
III	Namari	α	2.8109638	4.2709466
	Tono	β	6.9871075	4.7058778

basin numbered 48, the governing area per station being 145 km^2.

13. In actual calculation, the rainfall distribution is given for the rerpective areas of the basin, and for the dam the discharge curve so that the water stage and discharge curve at various points of the main stream in the lower reaches may be obtained. In this case, in order to find in a short time the rational operation of the dam it is necessary that calculation can be made automatically for obtaining the respective values variant with the precipitation in the upper reaches and with the operation of the dam. However, no computer has been utilized so far for calculation involving the dam operation. It is scheduled to install more facilities for the purpose.

FIGURE 2. KITAKAMI RIVER BASIN

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Fig-3 Thiessen network in the Kitakami River

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